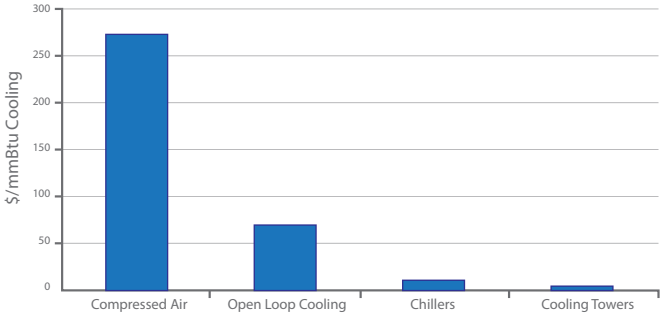
Better Plants
U.S. DEPARTMENT OF ENERGY

# Process Cooling System *Info Card*

## Top 5 Energy Conservation Measures

1. Convert chilled water systems from constant to variable flow by replacing 3-way with 2-way control valves and installing VFDs on distribution pumps
2. Convert condensing water systems from constant to variable flow by installing VFDs on condensing water pumps
3. Convert cooling tower fans from 1-speed or 2-speed to variable speed by installing VFDs
4. Reset chilled water supply temperature setpoints based on the process load
5. Reset condensing water entering temperature setpoints based on the ambient wet bulb temperature

## Process Cooling Systems' Cost Comparison




## Water Cooled Chiller Comparison

| Chiller Type | Capacity [1] Range (tons) | First Cost [2] Range ($/ton) | COP Range | IPLV Range (COP) |
|---|---|---|---|---|
| Reciprocating/ Scroll | 50–230 (400) | $200–$250 | 4.2–5.5 | 4.6–5.8 |
| Screw | 70–400 (1250) | $225–275 | 4.9–5.8 | 5.4–6.1 |
| Centrifugal | 200–2000 (10,000) | $180–$300 | 5.8–7.1 | 6.5–7.9 |
| Single-effect Absorption | 100–1700 | $300–$450 | 0.60–0.70 | 0.63–0.77 |
| Double-effect Absorption | 100–1700 | $300–$550 | 0.92–1.20 | 1.04–1.30 |
| Engine Driven | 100–3000 (10,000) | $450–$600 | 1.5–1.9 | 1.8–2.3 |

*[1]Capabilities in parentheses are maximum sizes available*
*[2] First cost includes allowance for contractor mark-ups*

*Courtesy of Energy Design Resources*

Better Plants
U.S. DEPARTMENT OF ENERGY

# Process Cooling System *Info Card*

## Rules of Thumb

1. 1°F increase of chilled water temperature improves the chiller efficiency by approximately 1.5%; 1°F decrease of condensing water temperature improves the chiller efficiency by approximately 1.5%
2. Pump sizing: 2.0 – 2.4 GPM/ton for chilled water and 2.5 – 3.0 GPM/ton for condensing water
3. Distribution pipe sizing: 10 ft/s water velocity or 4 ft w.c. pressure loss per 100 ft

## Unit Conversion

1. kW/ton = 12/EER; EER = COP × 3.413; kW/ton = 12/(COP × 3.413)
2. 1 refrigeration ton = 12,000 Btu/hr
   1 cooling tower ton = 15,000 Btu/hr
3. 1 HP =745.7 W; 1 ft w.c. = 0.433 psi
4. C = (F – 32) × (5/9)

## Integrated Partial Load Value (IPLV) Equation

$$IPLV = \frac{1}{\frac{1\%}{A} + \frac{42\%}{B} + \frac{45\%}{C} + \frac{12\%}{D}}$$

Where:
A = kW/ton @ 100% load
B = kW/ton @ 75% load
C = kW/ton @ 50% load
D = kW/ton @ 25% load

## Cooling Tower Water Consumption

**Cooling Tower Usage (Million Gallons/Year)**

| Chiller Tonnage | Cycles of Concentration | | | |
|---|---|---|---|---|
| | 3 | 5 | 7 | 8 |
| 100 | 2.0 | 1.7 | 1.6 | 1.5 |
| 200 | 4.0 | 3.4 | 3.1 | 3.1 |
| 400 | 8.0 | 6.7 | 6.3 | 6.1 |
| 600 | 12.1 | 10.0 | 9.4 | 9.2 |
| 800 | 16.1 | 13.4 | 12.5 | 12.3 |
| 1000 | 20.1 | 16.8 | 15.6 | 15.3 |
| 2000 | 40.2 | 33.5 | 31.2 | 30.6 |
| 3000 | 60.3 | 50.3 | 46.9 | 46.0 |
| 4000 | 80.4 | 67.0 | 62.6 | 61.3 |
| 5000 | 100.5 | 83.8 | 78.2 | 76.6 |

## Resources

1. ASHRAE Handbook: HVAC Systems and Equipment by ASHRAE
2. Chilled Water Plant Design Guide by Energy Design Resources



ORNL ID# 109862